Executive Summary

***Disclaimer*: This draft report was prepared to help the Department of Energy determine the barriers related to the deployment of new nuclear power plants but does not necessarily represent the views or policy of the Department.**

Introduction

- The National Energy Policy (NEP) recommended in May of 2001 that President George W. Bush support the expansion of nuclear energy in the United States as a major component of the national energy policy. Nuclear power offers the nation a low-cost, safe, and environmentally clean source of energy, usually in the form of electricity.
- More recently, President Bush called for the development of a U.S. strategy to reduce the carbon intensity of the American economy. Nuclear power has no carbon emissions. It also has no emissions of other important regulated environmental pollutants, such as nitrogen oxides, sulfur oxides, mercury, lead, and fine particulates.
- In addition, nuclear power, which now provides about 20% of the nation's electricity, provides diversity to the mix of fuels used to generate electricity. Fuel diversity is a critical element in energy security, and nuclear energy complements coal and natural gas as the leading fuels used in power generation. Stable allies provide most U.S. supplies of uranium fuel; supplies and prices are steady.
- As an element of its pursuit of the President's direction to expand the use of nuclear energy, the Department of Energy (DOE) is examining the business case for new nuclear power plants. A part of this examination, the current study is aimed at improving DOE's understanding of the business risks and risk management strategies associated with new nuclear power plants, particularly from the perspective of companies that design, build, finance, own, and operate them.

Primary Findings and Conclusions

- Nuclear power plants financed solely with private sector funds face barriers to commercial operation by 2010, due foremost to:
  - The existence of three key barriers (which some industry executives term "show-stopper" risks); these barriers and several critical areas of risk may limit a go-forward investment decision, and
  - Current conditions in electricity markets—particularly adequate supply and moderate prices, and the difficulty of projecting electricity demand and price ten years in the future.
- Nuclear industry and financial executives are looking to a major government role in managing the three key barriers (see pages *3-6* and *3-39*):
  - Waste disposal
  - Accident indemnification
  - Commissioning
- High capital costs, particularly for the first several plants using Generation III designs, jeopardize the market competitiveness of electricity generated in the first new plants. Within today's range of prices for wholesale power, these capital cost estimates for the next new nuclear plants might deliver economic returns that are below the cost of capital for generating companies, which are in the range of 10% – 12%, on an after-tax basis (assuming key project risks are mitigated to manageable levels).
- Our analysis shows, however, that once the first several plants have been built and operated, thereby removing several key uncertainties, nuclear power can be fully competitive in the electricity marketplace.
- To reach this point will require close cooperation between government and the private sector. Once the key barriers have been addressed, industry and the financial community are capable of addressing—to varying degrees—some of the other critical business risks associated with developing new nuclear power plants using new designs.
- Addressing the key barriers is the first essential step toward a new round of nuclear power plants in the United States. As noted repeatedly in this study, commitments to build new plants are highly unlikely until these three key barriers are addressed. Government (particularly DOE and the Nuclear Regulatory Commission [NRC]) is taking the lead, as follows:
  - Waste disposal: Government is making substantial progress toward opening Yucca Mountain, the repository for spent fuel. Congress voted to proceed.
  - Accident indemnification: The Administration is supporting re-authorization of the Price-Anderson Act.
  - Commissioning: NRC has not completed defining the acceptance criteria process through which new plants gain approval to begin operation. The new process will likely be tested in court, though, so the need to have a certain and finite process is not yet satisfied.

Primary Findings and Conclusions (continued)

- Difficulties in managing risks associated with the design, licensing, and construction of new reactors exacerbate the risk profile to potentially unmanageable levels in the view of these executives, without government participation. These critical risks include:
  - Regulatory risk not due to contractor fault that manifests itself in increased financing costs due to unforeseen and uncontrollable delays during plant construction and commissioning.
  - First-of-a-kind engineering costs for new plants.
  - Estimated high capital costs for new nuclear plants, and potential construction cost overruns for early plants using new designs.
  - Forecasting demand.
  - Transmission availability and congestion.
- The total risk-related cost premium for early nuclear power plants using Generation III light water reactor (LWR) technology is substantial. As an example, for AP1000 reactors, the first four two-reactor plants are likely to contribute varying amounts to this premium, which is comprised of three large elements:
  - First-of-a-kind engineering (FOAKE) costs: ~$200 – ~$350 million, based on the type of reactor and plant.
  - Learning-curve inefficiencies and contingencies on construction costs: At least $1 – $2 billion in total for the first 4 plants, on a base cost of $14 – $15 billion for 5 plants (11,000 MWe) in the case of AP1000s.
  - Extra interest costs associated with the other two elements: ~$300 – $400 million.
- These amounts do not include the cost of government efforts to address key barriers.
- The key barriers and other critical risks can be managed, but will require concerted and sustained efforts….
- Our analysis shows that the effective use of several risk mitigation techniques could enable DOE to help the private sector manage the deficits associated with the first several plants. These tools are equally applicable to support market introduction of new, high-priority technologies in many energy segments and to the successful, cost-effective construction of a variety of energy facilities and infrastructure. The mitigation strategy would include use of the following tools, some of which are likely to require new authority:
  - In addressing regulatory risk, a federal energy credit program could be established that includes a standby facility which incorporates an interest maintenance component, a debt principal buy-down option, and an equity option available to support the financing in the event of worst case delays or judicial intervention.
  - A standby construction cost overrun facility.
  - A government preferred equity facility to help fund first-of-a-kind engineering (FOAKE) costs.

Primary Findings and Conclusions *(continued)*

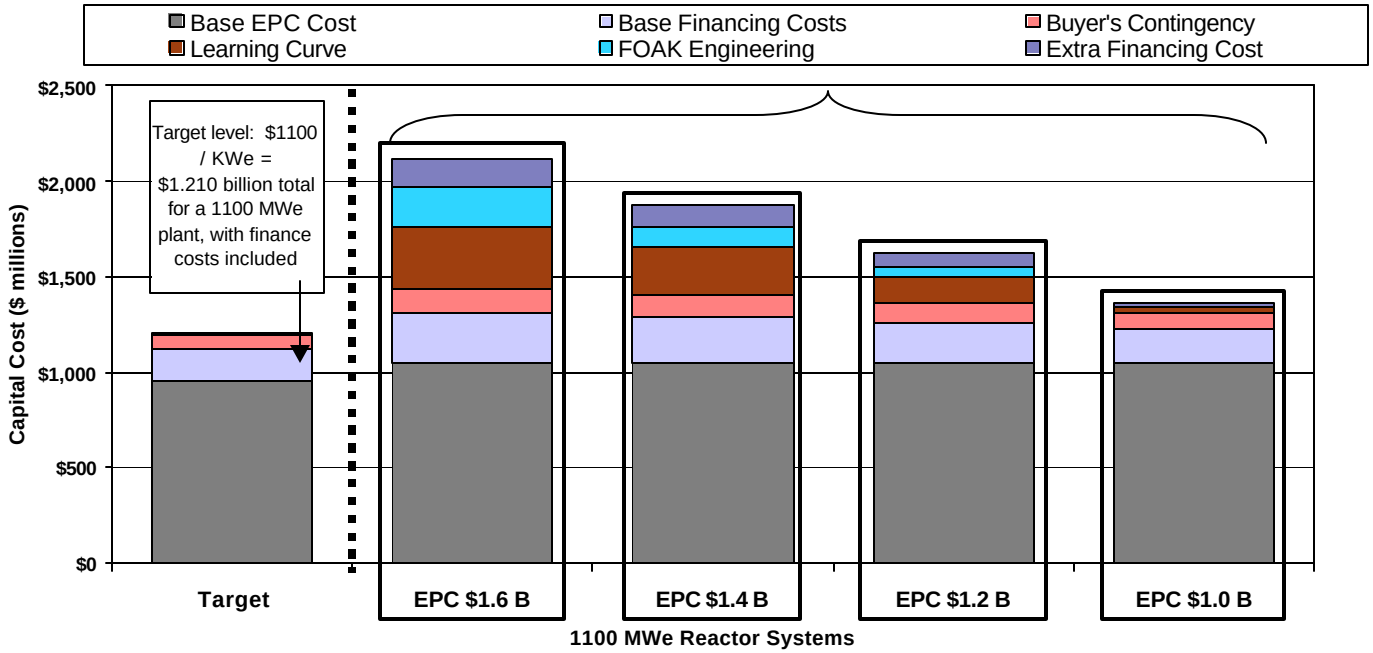
  - A direct loan facility (available under a federal energy credit program) to help reduce high capital costs. A power purchase agreement and an emissions credit program would augment revenues.
  - Additional insurance capacity with broader coverage.

- To address such a complex and diverse set of risks that arise when new nuclear power plants are under consideration, we recommend that DOE evaluate establishing a comprehensive federal energy credit program and other mechanisms. Such an energy credit program should be structured to incorporate a variety of credit facilities that address regulatory risks, higher initial construction and operating costs associated with new designs and technologies, and other factors that impede energy projects. Such a program will have broad applicability across the range of energy sectors and types of energy projects. It should provide the Department with broad flexibility to utilize a variety of innovative finance techniques that leverage the federal budget while attracting maximum amounts of private investment.
- Several other mechanisms could be used to help address risks for early plants, such as two that augment revenues:
  - A federal power purchase agreement at above-market rates would stabilize plant revenues and provide additional project revenues, while potentially limiting the impact on the federal budget by spreading expenses over a number of years.
  - Emissions credits for nuclear power generation could be an important technique for enhancing financial performance while leveling the playing field for nuclear power versus more carbon-intensive power sources. One important asset of nuclear power lies in its status as a clean source of electricity with respect to carbon emissions, mercury, and conventional air pollutants (e.g., acid rain precursors, such as SOx and NOx).

Capital Cost Column Chart: Range of Base Cases for 1100 MWe Reactor

The chart below depicts costs that would be associated with building a 1100 MWe "base case" reactor with a range of capital costs ($1.0 – $1.6 billion in Engineer-Procure-Construct [EPC] costs). The bulk of first-of-a-kind engineering (FOAKE) costs would be defrayed in higher-cost plants, and such plants would experience more learning-curve inefficiencies and contingencies in construction because the reactors would be earlier units and contractors would not be able to take as much advantage of modular construction. According to industry executives, a series of orders may be needed before any plants will be built; such a series of orders could be useful to spread the impact of FOAKE costs. Government and private-sector assistance could be applied to help address extra capital costs, but mechanisms and negotiated levels would vary.

Base Case Examples from Financial Model with Varying EPC Costs (not a time series)



Current Industry and Policy Challenges

- Despite significant advances in the operating performance of the majority of existing nuclear power plants and in the efficacy of new nuclear reactor designs, no orders for construction and commercial operation of a new nuclear generating facility have occurred since 1973. In fact, not much *baseload* capacity—whether nuclear, hydro-electric, or coal—has been ordered since the 1970s, other than some mine-mouth coal-fired plants, particularly in the western United States.
- The power generation and distribution industry has undergone significant change in recent years, and changes continue. Continued evolution and re-evaluation of deregulation at the federal and state level has contributed to higher levels of uncertainty, exacerbated by the California power crisis and the resulting PG&E insolvency. Significant credit concerns in the independent power sector are contributing to a difficult business climate that compounds the difficulty and complexity of decisions for new facility investment.
- The Department of Energy's Office of Nuclear Energy, Science and Technology (NE) has an extensive program to help address a number of the most important project development risks associated with new nuclear reactors. These programs focus most intensively on research and development for new reactor designs, Early Site Permits (ESP), and the combined Construction and Operating License (COL) process.
- Given the challenges facing the nuclear power industry, NE commissioned this study to examine the business case for new nuclear power plant development from the perspective of the business and financial issues that affect decisions to develop and invest in a new facility. This risk framework approach forms the heart of the analysis.

Objectives of the Study

Our goals in this study were to:

- Understand the risk management perspectives of investors, lenders, and industry, based on a strong understanding of the economics of production from new reactors and the risks inherent in such development.
- Evaluate market perspectives of the potential effectiveness of existing NE programs in addressing project development risks.
- Identify which risks strongly impede a positive private sector investment decision relative to building new nuclear power plants and understand the relative importance of these risk factors to nuclear power's competitiveness.
- Identify the critical risks that will remain after DOE actions based on current program authority and the actions the private sector must take to help manage critical risks to the construction and operation of new commercial reactors.
- Identify DOE actions to break down remaining critical barriers to new nuclear facility development.
- Understand what private sector and DOE programs and financial mechanisms are critical to creating a favorable investment climate.
- Identify alternative federal financing mechanisms for facilities and infrastructure that would be most effective in helping manage the remaining critical risks that appear to limit the competitiveness of new nuclear production facilities in U.S. electricity markets.
- Develop elements of an acquisition strategy for facilitating NE and DOE objectives.

Approach

- An integrated project team (IPT) was instituted to facilitate consideration of the complex issues involved in the project. The IPT membership consisted of the contractor, the DOE project manager, DOE's Office of Management, Budget and Evaluation, key NE staff, and senior NE management.
- An initial, substantial effort involved an analysis of the nuclear power industry and the parts of the financial community that are involved with nuclear power projects.
- A central effort involved extensive outreach to key non-DOE players to develop a clear understanding of current perspectives toward the risks that pertain to nuclear energy projects involving Generation III reactors.
- A risk framework was developed based on the analysis of data gathered and refined based on more than 25 interviews conducted with leading senior executives of manufacturers of nuclear power equipment; construction and engineering firms; power generators; electricity distribution companies; financial companies that are involved in financing, lending to, and insuring companies in the power generation and sales business; and non-governmental organizations interested in nuclear power.
- More than 20 of these individuals then participated in one of two roundtable discussions of the highlights of the interviews, along with NE and NRC. A key product of this effort is a deepened understanding of the financing gaps that impede development of new nuclear power plants.
- A conceptual financial model of the base case for a new nuclear power plant was developed. The model was built around a financial snapshot of a nuclear power project. It was utilized to calculate the financial impacts of both changes in values for key variables in the base case and to gauge the financial impact of the application of risk mitigation techniques and financing strategies.
- Several scenarios and sensitivity analyses were performed using the financial model to examine the impact on financial outcomes of changes in the base case and to project the impact on financial outcomes of a variety of potential risk mitigation methods that the private sector and government might use.
- Based on the risk framework, model results, and experience of the IPT members, a framework for risk mitigation was developed that arrays the key barriers and critical risks against potential risk mitigants. The potential usefulness of risk mitigation strategies in stimulating new nuclear plants was evaluated and recommendations for DOE roles were developed.

Overview of Findings and Conclusions

- Industry and financial participants were unanimous in their view that three key barriers are so important that they must be addressed to support a go-forward investment decision on new nuclear generating facilities. These three risk areas are waste disposal, accident, and the lack of certain and finite regulatory processes culminating in plant commissioning. Without immediate and decisive action on these three key barriers, power developers may not elect to go forward; no project financing would be possible, in any case.
- DOE is working to simultaneously strengthen and accelerate the regulatory processes that target site permitting (ESP) and the combination of construction and operating licenses (the new COL process), as well as on the acceptance process (ITAAC) for plant commissioning. Executives consulted in the study, however, view these programs with caution because they have not yet been finalized, and because they are untried and untested; the programs must be shown to be effective. Until improved regulatory processes have been finalized, tested, and affirmed, power developers and their investors and lenders will progress very cautiously because the new processes will be risky.
- Focused government assistance, modest relative to the private sector investment in nuclear power plants, could make a distinct difference in whether early orders are made in time to meet DOE's goal of startup of a new nuclear plant in the 2010 timeframe.
- The analysis shows that linkages exist between certain risk mitigation measures and other critical risks:
  - Regulatory risk not due to contractor fault that manifests itself in increased financing costs due to unforeseen and uncontrollable delays can best be mitigated through a stand-by credit facility, sized to address and capitalize these costs. Regulatory risks include commissioning risk, a key barrier, and plant siting (ESP) and construction and operating license (COL) processes. Lenders and equity investors can be made whole through government-provided principal buy-down or partial equity take-out provisions can make lenders and equity investors whole in a worst-case scenario.
  - FOAKE costs for new plant designs could be addressed if generating companies made an order for several plants, allowing FOAKE costs to be divided among the plants, or through a government-provided, quasi-equity instrument designed to infuse capital into the plant development and construction period. In the second case, the government could have the option to choose to share in the upside or to look for accelerated repayment as operating and financial performance improves. Payment would be senior to common equity returns, but subordinate to private debt.
  - High capital costs for new nuclear plants may drive power costs in excess of market-clearing rates. Mitigation options either would reduce borrowing costs, or alternatively, augment revenues from power sales.

Overview of Findings and Conclusions (continued)

At least two options could be used to reduce borrowing costs: subsidized federal loans and the allowance of tax-exempt financing for new nuclear power plants. These two options could be used to augment revenues:

- o The option of a federal power purchase agreement at above-market rates can provide additional project revenues, while potentially limiting the impact on the federal budget by spreading expenses over a number of years.
- o Emissions credits for nuclear power generation could be an important technique for enhancing financial performance while leveling the playing field versus more carbon-intensive power sources. One important asset of nuclear power lies in its status as a clean source of electricity, with respect to carbon emissions, mercury, and conventional air pollutants (e.g., acid rain precursors, such as SOx and NOx).

– Construction cost overruns are potentially outside the bounds of the financial capabilities of firms performing Engineer-Procure-Construct (EPC) work. Contracting firms may therefore command risk premiums that render capital costs non-competitive. Government-provided standby credit facilities could enable financings to go forward.

– Finally, insurance capacity for the nuclear industry for new development may be limited or too expensive. Certain risks have remained outside the bounds of policy limits—under the tacit assumption that the government will take up the role of insurer of last resort. Government indemnification may be required for new plants in order to continue to draw the necessary participation from private-market insurers.

- The costs to the government and funding process for some of these and other options must be evaluated further. Calculating the potential costs to the government would involve assessing probabilities of occurrence and analyzing the credit structures of specific projects.

Financial Sensitivity Analysis Findings

- A model of the economics and financing of a new nuclear power plant was developed to enable examination of:
  - The sensitivities of changes in key elements that control cost of electricity generated and internal rate of return (IRR) on base-case plant investment, and
  - The impact of several risk mitigation techniques on these critical cost elements.
- The sensitivity analysis confirms that nuclear power based on new designs which are closest to readiness faces significant competitive challenges from other sources of power (e.g., gas, coal). The base case cost of power for the first plant of a new design is expected to range from 3.8¢ – 4.2¢ / KWh, for the second and third plant may cost of 3.7¢ / KWh, while for the now-standard "Nth" plant the cost of power may be about 3.4¢ / KWh.
- The results of the sensitivity analysis showed that some variables influence the cost of power more than others.
  - Capital cost is the most significant variable in driving electricity price competitiveness and financial return.
  - Borrowing costs, on a stand-alone basis, appear to have somewhat less impact on price competitiveness and financial returns.
  - IRR and competitiveness are relatively insensitive to plant capacity factor changes.
  - Construction delays negatively impact IRR and plant competitiveness. Reducing construction delays improves IRR most for lower capital cost plants.
  - Fuel prices and plant heat rate (the efficiency in converting heat to electricity) drive electricity price competitiveness and financial return the least among the variables tested, primarily because they are so low now.
  - IRR is fairly sensitive to project debt : equity mix, but executives consulted during this effort indicated that financial markets are not likely to be flexible about project debt : equity mix (for capital-intensive baseload projects) because of rating agency concerns about the impact of leverage on balance sheets from the perspective of credit quality.
- The sensitivity analysis supports the conclusion that industry is not likely to build a first unit without government assistance because the first unit is unlikely to be competitive in today's market and its financial performance will fall below target IRR hurdle requirements.
- Several factors—the projected high cost of reactor equipment, a significant cost premium for the construction of early plants using new reactor designs, high first-of-a-kind engineering (FOAKE) costs, the long lead time for new plants, and increased uncertainty about electricity prices in a partially deregulated environment—combine to make the first new nuclear plants an unattractive business proposition, unaided. In addition, the unique regulatory issues associated with a nuclear facility test the limits of the market's capacity.

Near-Term Recommendations

- This study has laid out a series of critical risk categories and potential solutions to mitigate them. We believe that a number of immediate steps should be implemented to enable DOE's nuclear power objectives to be met without further federal financing support.
- Once the key barriers and critical risks are resolved and early units are built with support from mitigants, nuclear power is likely to be competitive, particularly if capital costs drop near $1100 / KWe or lower due to learning curve effects, or if power prices drift to slightly higher levels.
- Due to their very nature, the key barriers will be difficult or impossible to resolve immediately. Unless they are resolved, however, industry and financial executives have indicated that "go-forward" decisions on new plant development may be constrained. In that regard, we recommend that DOE place very high priority on continued efforts supporting reenactment of the Price-Anderson Act, the development of Yucca Mountain, and resolution of regulatory issues.
- We recommend addressing FOAKE costs through the use of a government-preferred equity investment facility. Improvements in the efficacy and cost-competitiveness of new reactor designs for the U.S. market are on the critical path to success for nuclear power. DOE efforts to help industry manage these costs must begin as soon as possible.
- In conjunction with these efforts, we recommend that DOE evaluate developing and implementing a diverse and robust federal energy credit program with multiple financing options, as well as other mechanisms for mitigating risks. The range of critical risks to new nuclear plants—and other new high-priority energy technologies, energy facilities, and other energy infrastructure—cannot be addressed fully with today's mitigants, plus only one or a few new mitigation tools. The diversity and fluidity of energy markets requires a diverse toolkit of risk mitigation techniques for the support of government goals.
- This comprehensive credit program should be structured to incorporate credit facilities to address regulatory risk, standby facilities to backstop construction cost overruns, and a direct loan option to provide low-cost capital on either a senior or a subordinate basis with favorable amortization terms of up to 30 years or, perhaps, longer.
- DOE should seek to design a program that provides the Department with broad flexibility to use a variety of innovative finance techniques that leverage the federal budget while attracting maximum amounts of private investment to the nuclear power industry.
- In addition, DOE should pursue mitigants that raise revenues generated by nuclear plants (e.g., emissions credits or power purchase agreements at above-market prices) have a substantial impact on improving IRR and addressing barriers, such as high capital costs. Hydrogen production and sale could be another possible boost to revenue for plants near refineries.

Near-Term Recommendations (continued)

- We believe that a federal energy credit program should be structured to provide assistance on the basis of a competitive selection process and that it incorporate the objectives of the Department, based on criteria that are consistent with the National Energy Policy. It is vital that the program be open to all energy sectors, such as generation facilities utilizing renewable energy fuels or clean coal technologies, wherever a critical gap exists between private sector's risk appetite and funding needs consistent with federal policies and program objectives.
- Last, DOE should seek the inclusion of nuclear power, a clean source of electricity, in any U.S. carbon emission credit program. Such a program would be an important technique for both enhancing the financial performance of nuclear power plants *and* leveling the playing field for nuclear power versus more carbon-intensive power sources.
- The study's results demonstrate that, through efforts to overcome the three key barriers and critical risks, and with the assistance of a comprehensive energy credit program and other risk mitigation tools to help industry and the financial community manage several critical risks, DOE can chart a viable path to enabling the nuclear power industry and other sources of efficient and clean energy to bring their technological advances into the marketplace and realize their various competitive potentials. Several other federal agencies already utilize federal credit authorities. Through the use of a new federal energy credit authority modeled after these other authorities and other innovative finance and programmatic techniques, DOE could more viably achieve its 2010 nuclear power and other energy objectives, while minimizing the drain on scarce budget resources.